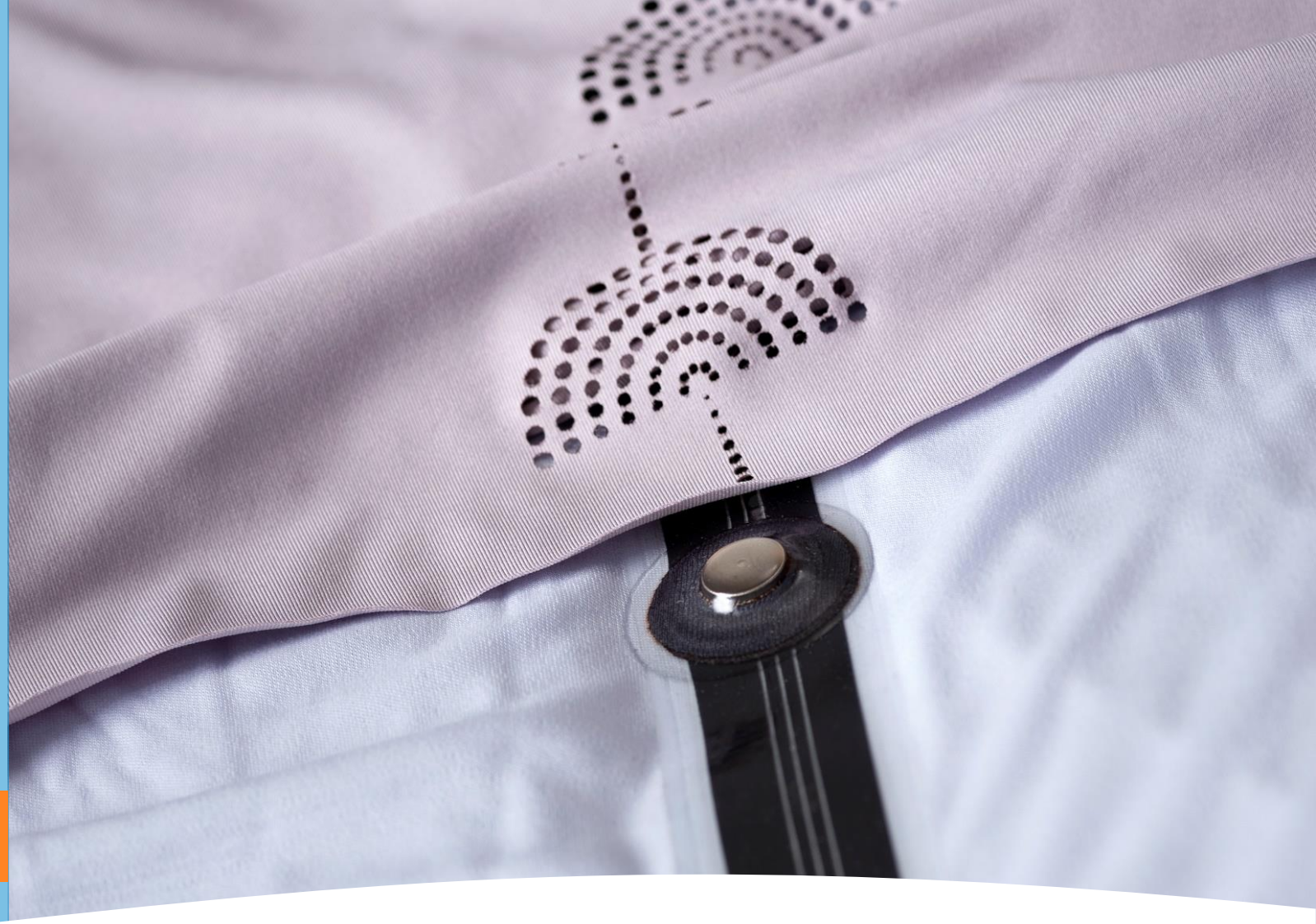
Minimizing Stress and Maximizing Vitality using Smart Clothing



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on Healthcare Solutions for Homecare

Holst Centre
Powered by imec & TNO

Stress - a worldwide societal concern

- Stress
  - **basic cause** of the majority **of all human** illness and disease
  - is negatively affecting our vitality

- Today **more than 84 %** of all Americans experience prolonged stress according to the American Physiological Association

www.apa.org/news/press/releases/2021/02/adults-stress-pandemic

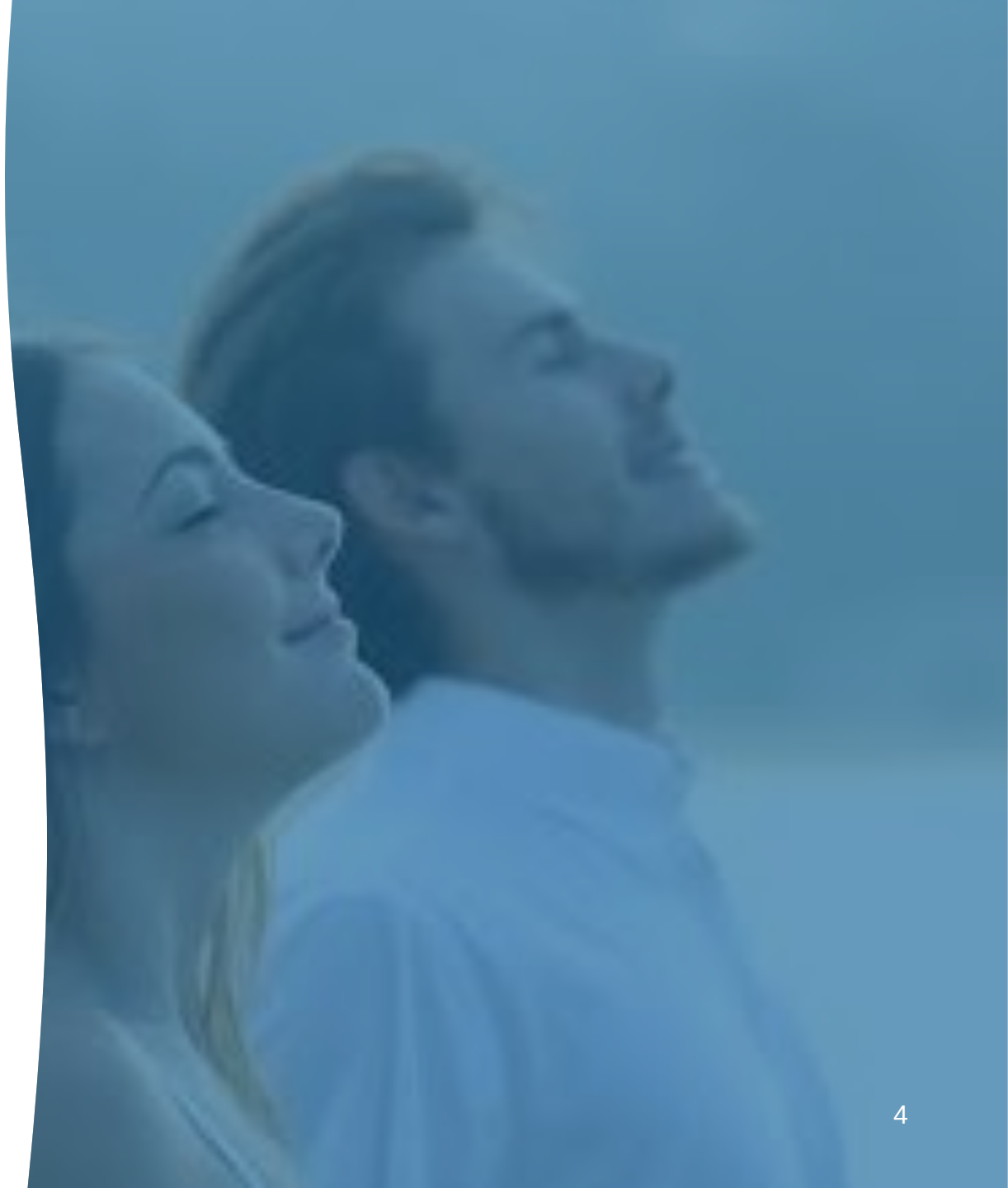
Prevention is better than cure

- Prevention of diseases requires highly personalized solutions that can be embedded into our everyday lives

Breathing as therapy

- Controlled breathing
  - influences neurophysiological processes
  - enhances therapeutic results

- Preventive therapy using relaxation techniques, as stress management, body awareness- and breathing exercises have **proven to improve the recovery** of heart diseases



doi:10.1097/01.hjr.0000166451.38593.de; doi 10.1007/s10072-016-2790-8; doi: 10.3389/fphys.2019.01176.

What if …

… we could prevent stress with a solution that works **intuitively**?

- a solution with a human touch
- a solution that helps people
- a solution embedded into our everyday lives

Humane technology

- At Holst Centre we seize the opportunity to make technology more humane

We focus on wearable technologies that **nurture the wearer**, by providing **comfort and support** and ensuring **resilience** in an increasingly dynamic, and often demanding, environment

Development of Smart Clothing Concepts

- Based on in-house knowhow and **patented** technologies
- **Designed for wearing comfort** using the power of textiles
- Fabrication processes **scalable for large volume** production
- **Seamlessly integration** of
  - vibrotactile actuators for guiding and stimulation of body awareness
  - sensors based on human bio-signal monitoring
- **Closed loop response**
  - feedback loop between sensor input and haptic output

The Power of Textiles and Clothing

- Textiles are **ubiquitous**, we are constantly in **touch** with them; everyone can **relate** to them
- Being a **soft, tactile second skin**, textiles and clothing provide comfort and security
- Clothing enables **freedom** of movement
- Clothing covers a **large surface** of the body, especially in comparison to wearable devices

- Integrating electronics in textiles to build on the **intimacy of clothing** and to augment its expressive and communicative qualities

Issho, a smart denim jacket by Pauline van Dongen
https://vimeo.com/207468324

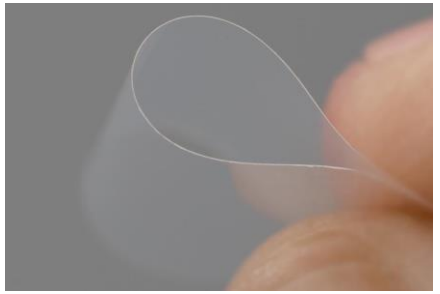
Why printed electronics?

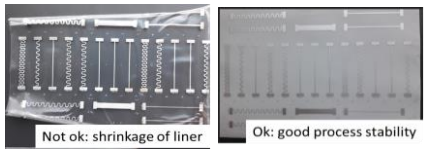
- Thin, stretchable & conformable
- High design freedom
- Ease of integration through lamination
- Low cost & easily multipliable
- Highly scalable in size (from cm^2 to m^2)
- All sensors and actuators are based on a compatible fabrication process: mix & match sensors/actuators or create multisensor nodes

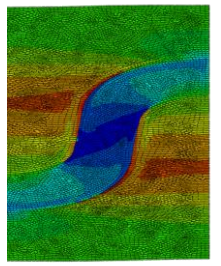
Steps of consideration - printing process

To fulfill the requirements, several components need to undergo analysis

1. **Selection of substrates:** based on availability, mechanical stretch properties and printability
2. **Selection of conductive inks:** based on availability and mechanical-electrical stretch properties
3. **Evaluation of printed stretchable substrates:** including stretchability, flexibility, conductivity, processability, morphology for the selected stack of substrates and inks

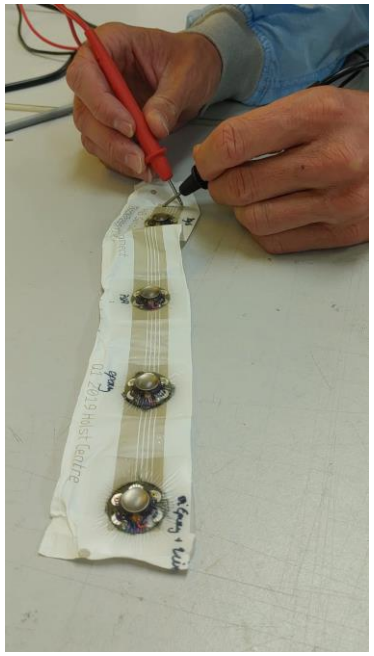






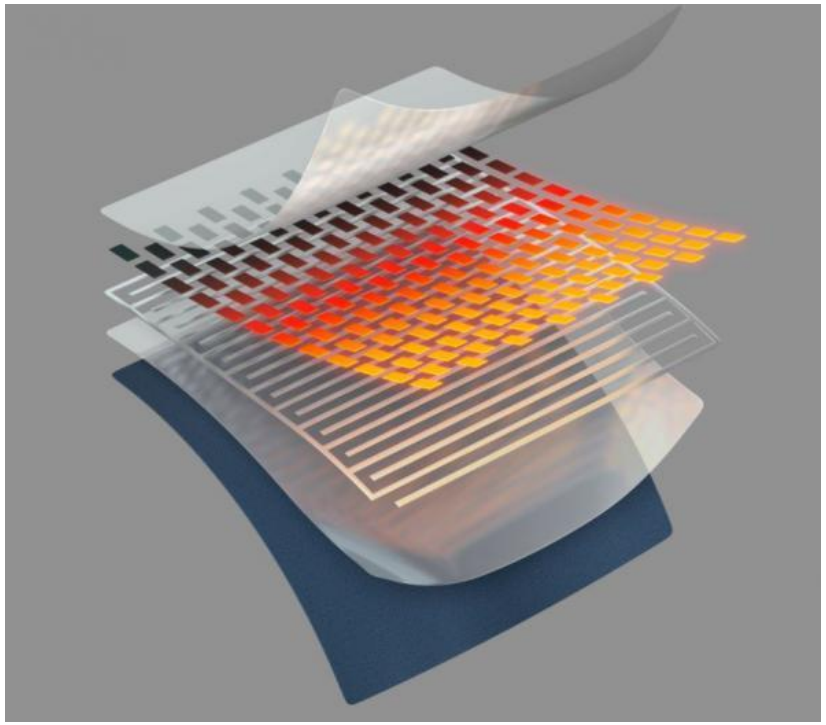
Seamless integration of sensors and actuators

- In-house technologies and processes scalable for large volume production
  - Stretchable and conformable circuits using **printed electronics**
  - **Patented processes** to bond vibration motors on the printed tracks
  - **Skin-contact bio-sensors** to measure respiratory status using the Nighthawk technology platform
  - **Seamless integration** to fabrics for soft and comfortable fit

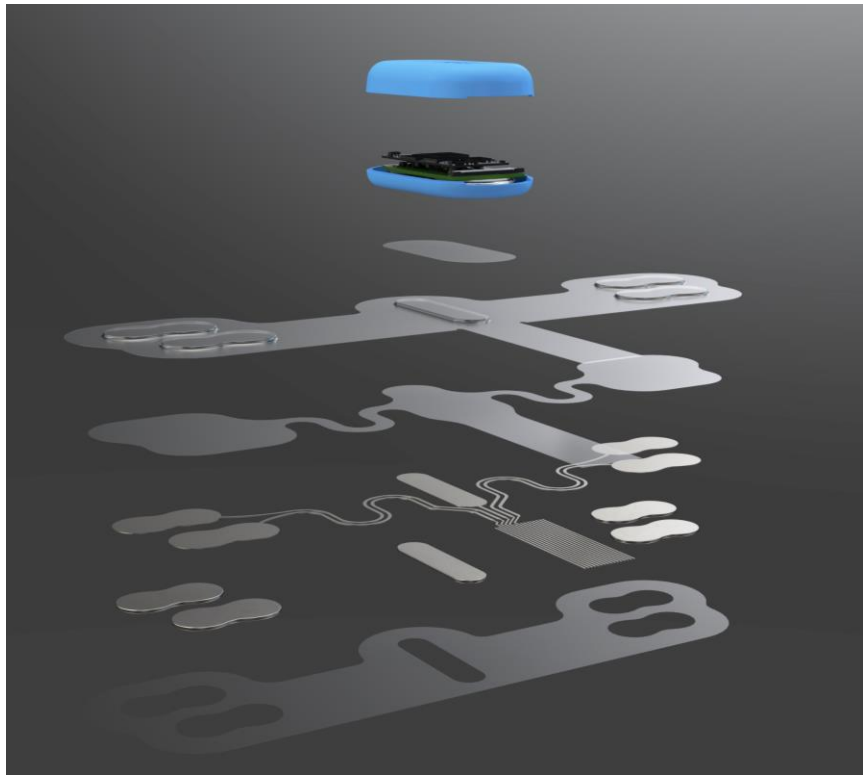


Building stacks of micro-structured layers

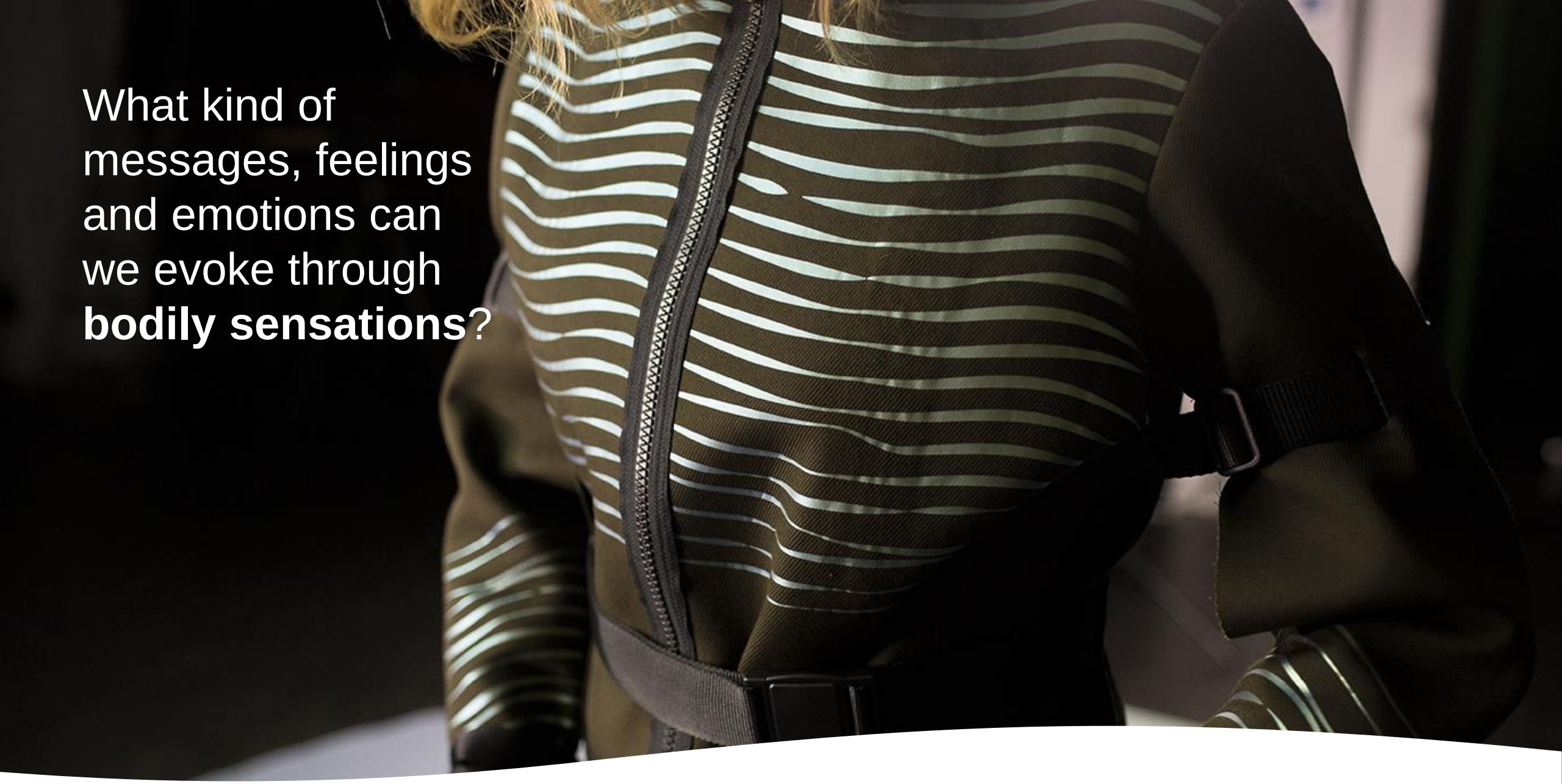
assembled with textiles using a heat bonding process



Graphics: DuPont



Graphics: Holst Centre



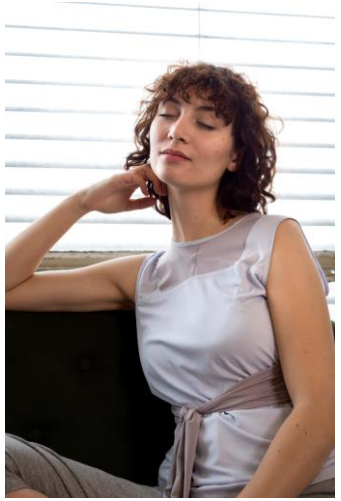
Body Wonders

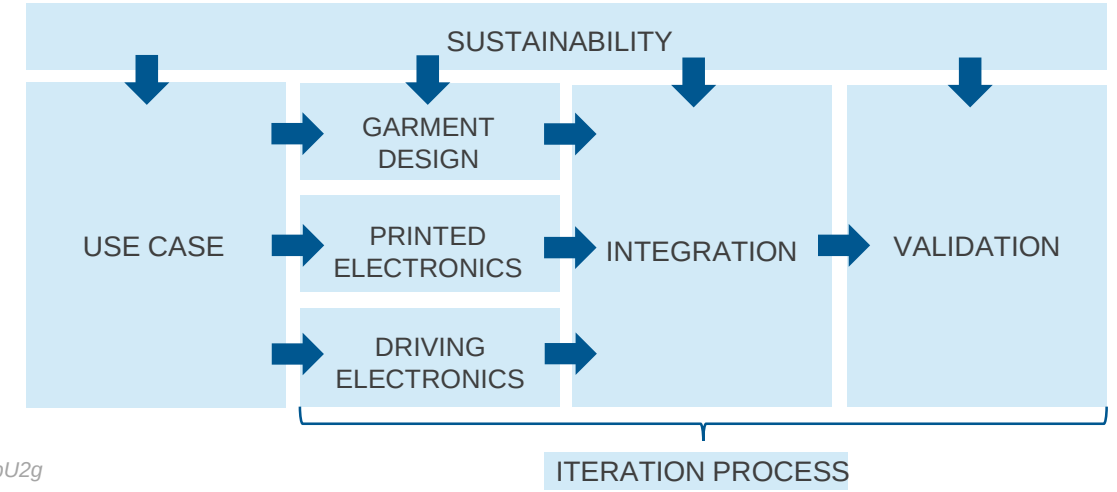
Open-ended exploration that lets people feel the potential of **haptic sensations** by wearing a jacket that contains 14 small vibration motors.

BodyWonders video: https://vimeo.com/474687721

MYSA /ˈmɪːsa/

- “Engaged in activity that is comfortable or pleasurable” *(Swedish)*
- Enhancing the **body awareness** to **reduce stress** and heal the body using **guided breathing** exercises using vibrotactile feedback
- **Holistic approach** uniting **design research, technology research** and **human experience research** to gain quantitative and qualitative results

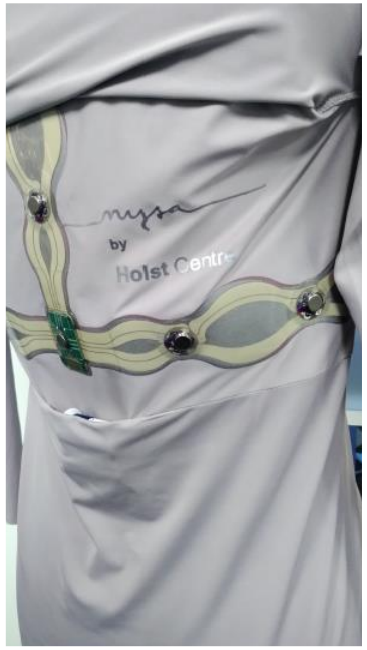


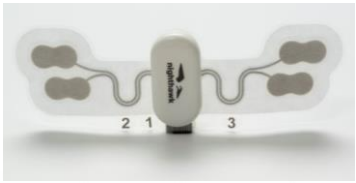


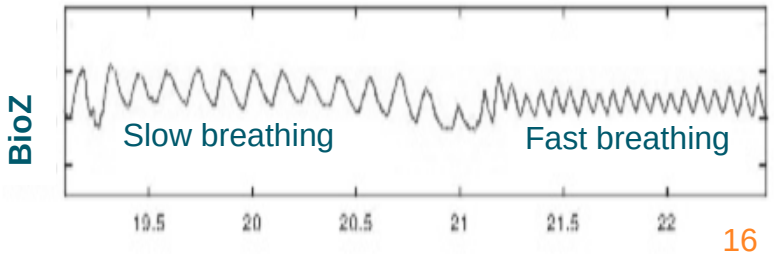
 MYSA video: https://www.youtube.com/watch?v=WCVyeS1bU2g

MYSA - Closed loop response

- '**Second skin**' shirt in Lyocell fabric made from natural and sustainable raw materials
- Monitoring stress by **respiratory frequency** and depth using integrated skin-contact bio-sensors
- **Algorithms detect changes** in breathing pattern
- **Feedback loop** between sensor input and haptic output
- Guided breathing by **haptic feedback** from integrated vibration motors
- Breathing exercises **adapted to actual breathing** rate achieving personalized interactions to decrease stress levels and heal body
- Solutions based on **patented technologies**







 MYSA video: https://www.youtube.com/watch?v=WCVyeS1bU2g

Concluding Reflections

- Stress is a serious threat to our vitality
- Rising need for **preventive healthcare solutions**
- Clothing integrated **haptics is a powerful tool** to strengthen body awareness using invisible, non-stigmatizing, tactile response
- TNO/Holst Centre spin-off for MYSA and Body Wonders technology concepts, to provide solutions to the market
- For more information or inquires, please contact charlotte.kjellander@tno.nl